

Attorney Docket No. 7594 P1
Customer No. 000049459

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CLAIMS

1. (Currently amended) A method for monitoring a membrane separation process comprising the steps of:

- (a) providing an industrial process, wherein within said industrial process there are feed streams comprising one or more solutes in an aqueous liquid;
- (b) providing a membrane capable of removing solutes from a feed stream by separating said feed stream into a first stream and a second stream, wherein said first stream is the permeate stream and said second stream is the concentrate stream;
- (c) selecting an inert fluorescent tracer and a tagged fluorescent agent, wherein the selection is made such that it is known in advance whether said inert fluorescent tracer and said tagged fluorescent agent are either
 - (i) capable of traveling through the membrane into the permeate stream either separately or together, or
 - (ii) not capable of passing through the membrane into the permeate stream either separately or together;
- (d) introducing the inert fluorescent tracer and tagged fluorescent agent into the feed stream;
- (e) providing one or more fluorometers, to enable the detection of the fluorescent signal of the inert fluorescent tracer in the feed stream and the concentrate and optionally the permeate and the detection of the fluorescent signal of the tagged fluorescent agent in the feed stream and the concentrate and optionally the permeate;
- (f) using the one or more fluorometers to detect the fluorescent signal of the inert fluorescent tracer in the feed stream and the concentrate and optionally the permeate and to detect the fluorescent signal of the tagged fluorescent agent in the feed stream and the concentrate and optionally the permeate;
- (g) converting the detected fluorescent signal of the inert fluorescent tracer into the concentration of the inert fluorescent tracer in the feed stream and the concentrate and optionally the permeate and converting the detected

Attorney Docket No. 7594 P1
Customer No. 000049459

fluorescent signal of the tagged fluorescent agent into the concentration of the tagged fluorescent agent in the feed stream and the concentrate and optionally the permeate.

2. (Currently amended) The method of claim 1 further comprising the step of:
h)-evaluating at least one process parameter specific to the membrane separation process based on the amount of the inert fluorescent tracer and the tagged fluorescent agent that are measured.
3. (Original) The method of claim 1 wherein the membrane separation process is selected from the group consisting of a cross-flow membrane separation process and a dead-end flow membrane separation process.
4. (Original) The method of claim 3 wherein the membrane separation process is selected from the group consisting of reverse osmosis, ultrafiltration, microfiltration, nanofiltration, electrodialysis, electrodeionization, pervaporation, membrane extraction, membrane distillation, membrane stripping and combinations thereof.
5. (Original) The method of claim 3 wherein the membrane separation process is selected from the group consisting of reverse osmosis, ultrafiltration, microfiltration and nanofiltration.
6. (Original) The method of claim 1 wherein the inert fluorescent tracer is selected from the group consisting of 3,6-acridinediamine, N,N,N',N'-tetramethyl-, monohydrochloride; 2-anthracenesulfonic acid sodium salt; 1,5-anthracenedisulfonic acid; 2,6-anthracenedisulfonic acid; 1,8-anthracenedisulfonic acid; anthra[9,1,2-cde]benzo[rst]pentaphene-5,10-diol, 16,17-dimethoxy-, bis(hydrogen sulfate), disodium salt; bathophenanthrolinedisulfonic acid disodium salt; amino 2,5-benzene disulfonic acid; 2-(4-aminophenyl)-6-methylbenzothiazole; 1H-

Attorney Docket No. 7594 P1
Customer No. 000049459

benz[de]isoquinoline-5-sulfonic acid, 6-amino-2,3-dihydro-2-(4-methylphenyl)-1,3-dioxo-, monosodium salt; phenoxazin-5-ium, 1-(aminocarbonyl)-7-(diethylamino)-3,4-dihydroxy-, chloride; benzo[a]phenoxazin-7-ium, 5,9-diamino-, acetate; 4-dibenzofuransulfonic acid; 3-dibenzofuransulfonic acid; 1-ethylquinaldinium iodide; fluorescein; fluorescein, sodium salt; Keyfluor White ST; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-[[4-[bis(2-hydroxyethyl)amino]-6-[(4-sulfophenyl)amino]-1,3,5-triazin-2-yl]amino]-, tetrasodium salt; C.I. Florescent Brightener 230; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-[[4-[bis(2-hydroxyethyl)amino]-6-[(4-sulfophenyl)amino]-1,3,5-triazin-2-yl]amino]-, tetrasodium salt; 9,9'-biacridinium, 10,10'-dimethyl-, dinitrate; 1-deoxy-1-(3,4-dihydro-7,8-dimethyl-2,4-dioxobenzo[g]pteridin-10(2H)-yl)- ribitol; mono-, di-, or tri-sulfonated naphthalenes selected from the group consisting of 1,5-naphthalenedisulfonic acid, disodium salt (hydrate); 2-amino-1-naphthalenesulfonic acid; 5-amino-2-naphthalenesulfonic acid; 4-amino-3-hydroxy-1-naphthalenesulfonic acid; 6-amino-4-hydroxy-2-naphthalenesulfonic acid; 7-amino-1,3-naphthalenesulfonic acid, potassium salt; 4-amino-5-hydroxy-2,7-naphthalenedisulfonic acid; 5-dimethylamino-1-naphthalenesulfonic acid; 1-amino-4-naphthalene sulfonic acid; 1-amino-7-naphthalene sulfonic acid; and 2,6-naphthalenedicarboxylic acid, dipotassium salt; 3,4,9,10-perylenetetra-carboxylic acid; C.I. Fluorescent Brightener 191; C.I. Fluorescent Brightener 200; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-(4-phenyl-2H-1,2,3-triazol-2-yl)-, dipotassium salt; benzenesulfonic acid, 5-(2H-naphtho[1,2-d]triazol-2-yl)-2(2-phenylethenyl)-, sodium salt; 1,3,6,8-pyrenetetrasulfonic acid, tetrasodium salt; pyranine; quinoline; 3H-phenoxazin-3-one, 7-hydroxy-, 10-oxide; xanthylium, 9-(2,4-dicarboxyphenyl)-3,6-bis(diethylamino)-, chloride, disodium salt; phenazinium, 3,7-diamino-2,8-dimethyl-5-phenyl-, chloride; C.I. Fluorescent Brightener 235; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-[[4-[bis(2-hydroxyethyl)amino]-6-[(4-sulfophenyl)amino]-1,3,5-triazin-2-yl]amino]-, tetrasodium salt; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-[[4-[(2-

Attorney Docket No. 7594 P1
Customer No. 000049459

hydroxypropyl)amino]-6-(phenylamino)-1,3,5-triazin-2-yl]amino]-, disodium salt; xanthylum, 3,6-bis(diethylamino)-9-(2,4-disulfophenyl)-, inner salt, sodium salt; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-[[4-((aminomethyl)(2-hydroxyethyl)amino)-6-(phenylamino)-1,3,5-triazin-2-yl]amino]-, disodium salt; Tinopol DCS; benzenesulfonic acid, 2,2'-([1,1'-biphenyl]-4,4'-diyl)-2,1-ethenediyl)bis, disodium salt; benzenesulfonic acid, 5-(2H-naphtho[1,2-d]triazol-2-yl)-2-(2-phenylethenyl)-, sodium salt; 7-benzothiazolesulfonic acid, 2,2'-(1-triazene-1,3-diyl)-4,1-phenylene)bis[6-methyl-, disodium salt; and all ammonium, potassium and sodium salts thereof; and all mixtures thereof.

7. (Original) The method of claim 1 wherein the inert fluorescent tracer is selected from the group consisting of 1-deoxy-1-(3,4-dihydro-7,8-dimethyl-2,4-dioxobenzo[g]pteridin-10(2H)-yl)-D ribitol; fluorescein; fluorescein, sodium salt; 2-anthracenesulfonic acid sodium salt; 1,5-anthracenedisulfonic acid; 2,6-anthracenedisulfonic acid; 1,8-anthracenedisulfonic acid; mono-, di-, or tri-sulfonated naphthalenes selected from the group consisting of 1,5-naphthalenedisulfonic acid, disodium salt (hydrate); 2-amino-1-naphthalenesulfonic acid; 5-amino-2-naphthalenesulfonic acid; 4-amino-3-hydroxy-1-naphthalenesulfonic acid; 6-amino-4-hydroxy-2-naphthalenesulfonic acid; 7-amino-1,3-naphthalenesulfonic acid, potassium salt; 4-amino-5-hydroxy-2,7-naphthalenedisulfonic acid; 5-dimethylamino-1-naphthalenesulfonic acid; 1-amino-4-naphthalene sulfonic acid; 1-amino-7-naphthalene sulfonic acid; and 2,6-naphthalenedicarboxylic acid, dipotassium salt; 3,4,9,10-perylenetetracarboxylic acid; C.I. Fluorescent Brightener 191; C.I. Fluorescent Brightener 200; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-(4-phenyl-2H-1,2,3-triazol-2-yl)-, dipotassium salt; benzenesulfonic acid, 5-(2H-naphtho[1,2-d]triazol-2-yl)-2-(2-phenylethenyl)-, sodium salt; 1,3,6,8-pyrenetetrasulfonic acid, tetrasodium salt; pyranine; quinoline; 3H-phenoxazin-3-one, 7-

Attorney Docket No. 7594 P1

Customer No. 000049459

hydroxy-, 10-oxide; xanthylum, 9-(2,4-dicarboxyphenyl)-3,6-bis(diethylamino)-, chloride, disodium salt; phenazinium, 3,7-diamino-2,8-dimethyl-5-phenyl-, chloride; C.I. Fluorescent Brightener 235; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-[[4-[bis(2-hydroxyethyl)amino]-6-[(4-sulfophenyl)amino]-1,3,5-triazin-2-yl]amino]-, tetrasodium salt; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-[[4-[4-[2-hydroxypropyl)amino]-6-(phenylamino)-1,3,5-triazin-2-yl]amino]-, disodium salt; xanthylum, 3,6-bis(diethylamino)-9-(2,4-disulfophenyl)-, inner salt, sodium salt; benzenesulfonic acid, 2,2'-(1,2-ethenediyl)bis[5-[[4-[(aminomethyl)(2-hydroxyethyl)amino]-6-(phenylamino)-1,3,5-triazin-2-yl]amino]-, disodium salt; Tinopol DCS; benzenesulfonic acid, 2,2'-([1,1'-biphenyl]-4,4'-diyl)-2,1-ethenediyl)bis-, disodium salt; benzenesulfonic acid, 5-(2H-naphtho[1,2-d]triazol-2-yl)-2-(2-phenylethenyl)-, sodium salt; 7-benzothiazolesulfonic acid, 2,2'-(1-triazene-1,3-diyl)-4,1-phenylene)bis[6-methyl-, disodium salt; and all ammonium, potassium and sodium salts thereof; and all mixtures thereof.

8. (Original) The method of claim 1 wherein the inert fluorescent tracer is selected from the group consisting of 1,3,6,8-pyrenetetrasulfonic acid tetrasodium salt; 1,5-naphthalenedisulfonic acid disodium salt (hydrate); xanthylum, 9-(2,4-dicarboxyphenyl)-3,6-bis(diethylamino)-, chloride, disodium salt; 1-deoxy-1-(3,4-dihydro-7,8-dimethyl-2,4-dioxobenzo[g]pteridin-10(2H)-yl) - D-ribitol; fluorescein; fluorescein, sodium salt; 2-anthracenesulfonic acid sodium salt; 1,5-anthracenedisulfonic acid; 2,6-anthracenedisulfonic acid; 1,8-anthracenedisulfonic acid; and mixtures thereof.
9. (Original) The method of claim 1 wherein the tagged fluorescent agent comprises a water-soluble polymer tagged with at least one fluorescent group.

Attorney Docket No. 7594 P1
Customer No. 000049459

10. (Original) The method of claim 9 wherein the fluorescent group is selected from the group consisting of hydroxy allyloxypropyl naphthalimide quat, 4-methoxy-N-(3-N'N'-dimethylaminopropyl) naphthalimide, 2 hydroxy-3-allyloxypropyl quat, 8-(3-vinylbenzyloxy)-1, 3, 6-pyrene trisulfonic acid; 8-(4-vinylbenzyloxy)-1,3,6-pyrene trisulfonic acid, 8-(allyloxy)-1,3,6-pyrene trisulfonic acid, 1-(substituted) naphthalene, 9-(substituted) anthracene, 2-(substituted) quinoline monohydrochloride, 2-(substituted) benzimidazole, 5-(substituted) fluorescein, 4-(substituted) coumarin, coumarin derivatives, 3-(substituted)-6, 7-dimethoxy-1-methyl-2(1H)-quinoxazolinone, mixtures thereof and derivatives thereof.

11. (Original) The method of claim 9 wherein the water-soluble polymer comprises a monomer selected from the group consisting of acrylamide, acrylic acid, methacrylamide, vinyl acetate, dimethylaminoethyl acrylate methyl chloride quaternary salt, dimethylaminoethyl acrylate benzyl chloride quaternary salt, diallyldimethyl ammonium chloride, N-vinyl formamide; dimethylaminoethyl methacrylate methyl chloride quaternary salt, dimethylaminoethyl methacrylate benzyl chloride quaternary salt, methacrylamino propyl trimethyl ammonium chloride, acrylamidopropyl trimethyl ammonium chloride, and combinations thereof.

12. (Original) The method of claim 1 wherein the tagged fluorescent agent comprises a copolymer of acrylate and acrylamide tagged with a hydroxy allyloxypropyl naphthalimide quat in an amount of about 2% or less by weight of the copolymer.

13. (Original) The method of claim 1 wherein the inert fluorescent tracer and the tagged fluorescent agent are each introduced into the feed stream in an amount from about 5 ppt to about 1000 ppm.

14. (Original) The method of claim 1 wherein the inert fluorescent tracer and the tagged fluorescent agent are each introduced into the feed stream in an amount from about 1 ppb to about 50 ppm.

Attorney Docket No. 7594 P1
Customer No. 000049459

15. (Original) The method of claim 1 wherein the inert fluorescent tracer and the tagged fluorescent agent are each introduced into the feed stream in an amount from about 5 ppb to about 50 ppb.

16. (Original) The method of claim 1 wherein the inert fluorescent tracer and tagged fluorescent agent are added to a formulation capable of treating scaling and/or fouling prior to addition to the feed stream.

17. (Original) The method of Claim 1 further comprising the step of: determining the ratio of the amount of inert fluorescent tracer to the tagged fluorescent agent based on the concentration of the inert fluorescent tracer and the concentration of the tagged fluorescent agent in each of the streams where the concentrations were measured.

18. (Currently amended) A method for detecting damage to a membrane used in a membrane separation process comprising the steps of:

- (a) providing an industrial process, wherein within said industrial process there are feed streams comprising one or more solutes in an aqueous liquid;
- (b) providing a membrane capable of removing solutes from a feed stream by separating said feed stream into a first stream and a second stream, wherein said first stream is the permeate stream and said second stream is the concentrate stream;
- (c) selecting an inert fluorescent tracer and a tagged fluorescent agent; wherein the selection is made such that it is known in advance that one or both of said inert fluorescent tracer and said tagged fluorescent agent are not capable of passing through the membrane into the permeate stream;
- (d) introducing the inert fluorescent tracer and tagged fluorescent agent into the feed stream;
- (e) providing one or more fluorometers, to enable the detection of the fluorescent signal of the inert fluorescent tracer in the feed stream and in the

Attorney Docket No. 7594 P1
Customer No. 000049459

- permeate stream and the detection of the fluorescent signal of the tagged fluorescent agent in the feed stream and in the permeate stream;
- (f) using the one or more fluorometers to detect the fluorescent signal of the inert fluorescent tracer in the feed stream and in the permeate stream and to detect the fluorescent signal of the tagged fluorescent agent in the feed stream and in the permeate stream; wherein, if one or both of the fluorescent signals of the inert fluorescent tracer and the tagged fluorescent agent are found in the permeate then this indicates the membrane is damaged in some way.